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(54)【発明の名称】　電動パワーステアリング装置

(57)【特許請求の範囲】

【請求項１】　ステアリング系の操舵トルクを検出する操舵トルクセンサと、ステアリング系に操舵補助力を作用させる電動機と、前記操舵トルクセンサからの操舵トルク信号に基づいて前記電動機を駆動する目標電流信号を決定する目標電流設定手段、およびこの目標電流設定手段からの目標電流信号と電動機電流検出手段からの電動機電流信号の偏差に基づいて前記電動機を制御し、少なくとも比例要素と積分要素を備えた比例・積分制御手段からなる制御手段と、を備えた電動式パワーステアリング装置において、
前記制御手段は、車両の速度を検出する車速センサからの車速信号に基づいて前記比例要素の比例感度および前記積分要素の積分ゲインを低車速時よりも高車速時に大きく設定する比例・積分係数設定手段を備えたことを特徴とする電動パワーステアリング装置。

【請求項２】　ステアリング系の操舵トルクを検出する操舵トルクセンサと、ステアリング系に操舵補助力を作用させる電動機と、前記操舵トルクセンサからの操舵トルク信号に基づいて前記電動機を駆動する目標電流信号を決定する目標電流設定手段、この目標電流設定手段からの目標電流信号と電動機電流検出手段からの電動機電流信号の偏差を演算して偏差信号を出力する偏差演算手段、前記偏差信号に基づいて前記電動機を制御し、少なくとも比例要素と積分要素を備えた比例・積分制御手段からなる制御手段と、を備えた電動式パワーステアリング装置において、
前記制御手段は、前記偏差演算手段と前記比例・積分制御手段との間に、車両の速度を検出する車速センサからの車速信号に基づいて前記偏差信号を低車速時よりも高

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車速時に大きく設定する補正手段を備えたことを特徴とする電動パワーステアリング装置。

【請求項３】　ステアリング系の操舵トルクを検出する操舵トルクセンサと、ステアリング系に操舵補助力を作用させる電動機と、前記操舵トルクセンサからの操舵トルク信号に基づいて前記電動機を駆動する目標電流信号を決定する目標電流設定手段、この目標電流設定手段からの目標電流信号と電動機電流検出手段からの電動機電流信号の偏差を演算して偏差信号を出力する偏差演算手段、前記偏差信号に基づいて前記電動機を制御し、少なくとも比例要素と積分要素を備えた比例・積分制御手段からなる制御手段と、を備えた電動式パワーステアリング装置において、

前記制御手段は、車両の速度を検出する車速センサからの車速信号に基づいて前記目標電流信号および前記電動機電流信号をそれぞれ低車速時よりも高車速時に大きく設定する補正手段を備えたことを特徴とする電動パワーステアリング装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、電動機の動力を操舵補助力としてステアリング系に作用させ、ドライバの操舵力を軽減する電動パワーステアリング装置に係り、特に車両の低車速領域ではステアリング系の音や振動の発生を防止し、車両の高車速領域ではステアリング系の操舵応答性を良くする電動パワーステアリング装置に関する。

【０００２】

【従来の技術】従来の電動パワーステアリング装置において、ドライバのハンドル操作に伴って発生する操舵トルクを操舵トルクセンサで検出し、検出した操舵トルク信号を電動機を駆動する目標電流信号に変換し、目標電流信号と電動機に実際に流れる電動機電流に対応した電動機電流信号との偏差信号にＰＩ（比例・積分）またはＰＩＤ（比例・積分・微分）制御を施した信号を発生し、この信号に基づいて生成した電動機制御信号（例えば、ＰＷＭ信号）で電動機を駆動してステアリング系に操舵補助力を作用させるようにしたものは知られている。

【０００３】このような従来の電動パワーステアリング装置は、電動機電流信号を目標電流信号にフィードバック（負帰還）させてＰＩまたはＰＩＤ制御する構成のため、偏差信号が速やかに０になるよう制御され、電動機電流は目標電流信号で設定された値に収束して電動機を駆動し、操舵トルク信号に対応した操舵補助力が得られる。

【０００４】図７に従来の電動パワーステアリング装置の要部ブロック構成図を示す。なお、図７は制御系にＰＩ（比例・積分）制御を施した例を示す。図７において、電動パワーステアリング装置５０は、操舵トルクセンサ１２、車速センサ１４、制御手段５１、電動機駆動手段１６、電動機電流検出手段１８、電動機１０から構成される。

【０００５】制御手段５１はマイクロプロセッサを基本に各種演算手段、比較・処理手段、メモリ等から構成され、目標電流設定手段５２、偏差演算手段５３、比例・積分制御手段５４、制御信号発生手段５５を備える。

【０００６】操舵トルクセンサ１２はドライバのハンドル操作に対応した操舵トルクをアナログの電気信号として検出し、操舵トルク信号T_Sが目標電流設定手段５２に供給される。車速センサ１４は車両の速度に対応した周波数の電気的なパルス信号として検出し、車速信号V_Sが目標電流設定手段５２に供給される。

【０００７】目標電流設定手段５２は、操舵トルクセンサ１２から供給される操舵トルク信号T_Sをディジタルの操舵トルク信号T_Dに変換し、この操舵トルク信号T_Dと車速センサ１４から供給される車速信号V_Sに基づいて予め設定されている目標電流信号I_{MS}に変換し、車速V_S（V_L、V_M、V_H）をパラメータにした操舵トルク信号T_Dに対する目標電流信号I_{MS}を偏差演算手段５３に出力するよう構成される。

【０００８】図８に車速をパラメータとした操舵トルク信号（T_D）—目標電流信号（I_{MS}）特性図（テーブル１）を示す。図８において、車速V_L、V_MおよびV_Hはそれぞれ低車速領域、中車速領域および高車速領域を示し、操舵トルク信号T_Dが同じであっても、車速V_Sが増加（$V_L \rightarrow V_M \rightarrow V_H$）するに伴い、目標電流信号$I_{MS}$は減少するよう予め設定されている。

【０００９】このように、目標電流設定手段５２は、低車速領域（$V_S=V_L$）では電動機１０を目標電流信号I_{MS}に対応した大きな電動機電流I_Mで駆動して充分大きな操舵補助力が得られ、一方、高車速領域（$V_S=V_H$）では電動機１０を目標電流信号I_{MS}に対応した小さな電動機電流I_Mで駆動して操舵補助力を抑え、操舵の安定性が得られるよう構成される。

【００１０】偏差演算手段５３は、目標電流信号I_{MS}と電動機電流検出手段１８で検出され、電動機電流I_Mに対応させてディジタル信号に変換した電動機電流信号I_{MO}の偏差（$=I_{MS}-I_{MO}$）を演算し、偏差信号ΔIが比例・積分制御手段５４に提供される。

【００１１】比例・積分制御手段５４は、偏差信号ΔIを比例感度K_P倍する比例要素と、偏差信号ΔI（$=I_{MS}-I_{MO}$）を積分ゲインK_Iで積分制御する積分要素を並列接続して構成され、偏差信号ΔIに比例・積分演算を施し、比例・積分信号I_{PI}が制御信号発生手段５５に供給される。比例・積分信号I_{PI}は比例感度K_Pおよび積分ゲインK_Iを用いて数１で表わされる。

【００１２】

【数１】 $I_{PI}=K_P*\Delta I+(K_I/p)*\Delta I$

ただし、ｐはヘビサイド演算子

【００１３】なお、比例感度K_Pおよび積分ゲインK_Iの値を大きく設定することにより、電動機電流信号I_{MO}（電動機電流I_Mに対応）を速やかに目標電流信号I_{MS}に収束（偏差信号$\Delta I = 0$）させることができる。

【００１４】制御信号発生手段５５はＰＷＭ（パルス幅変調）信号発生手段を備え、比例・積分信号I_{PI}の大きさと方向に対応したＰＷＭ信号V_{PWM}が電動機制御信号V_0として電動機駆動手段１６に供給され、電動機駆動手段１６から電動機電圧V_Mで電動機１０が駆動される。

【００１５】また、電動機制御信号V_0により電動機１０が駆動されて電動機電流I_Mが流れるが、電動機電流検出手段１８が電動機電流I_Mを検出し、対応した電動機電流信号I_{MO}が偏差演算手段５３に帰還される。

【００１６】このように、従来の電動パワーステアリング装置５０は、目標電流信号I_{MS}に電動機電流I_Mに対応したをフィードバック（負帰還）させ、偏差信号ΔIに比例・積分制御を施すよう構成したので、電動機電流信号I_{MO}を速やかに目標電流信号I_{MS}に収束させ、操舵トルクに対応した電動機動力が得られ、応答性のよい所望の操舵補助力をステアリング系に作用させることが可能となる。

【００１７】

【発明が解決しようとする課題】従来の電動パワーステアリング装置５０は、比例・積分制御手段５４の比例感度K_Pおよび積分ゲインK_Iの値が車速に対して一定値に設定されているため、車両が低車速領域V_Lで走行する場合と高車速領域V_Hで走行する場合では、車両挙動が異なり以下のような課題がある。

【００１８】車両が低車速領域V_Lで走行する場合、図８に示すように目標電流信号I_{MS}が大きい値に設定されているため、比例感度K_Pおよび積分ゲインK_Iを大きくすると、制御手段５１のゲインが必要以上に高くなってステアリング系にノイズ等に起因する音や振動が発生する課題がある。

【００１９】また、車両が高車速領域V_Hで走行する場合、目標電流信号I_{MS}が小さい値に設定されているため、比例感度K_Pおよび積分ゲインK_Iを小さくすると、制御手段５１の応答に遅れを生じ、ハンドル操作をしてから車輪が操向するまでに時間遅れがあり、操舵応答性が低下する課題がある。

【００２０】一般的に操舵特性は、停車時および低速走行時には大きな操舵補助力が要求されるとともに、ステアリング系に発生する音や振動の低減が要求される。しかし、停車時および低速走行時の操舵応答性については、多少遅くとも気にならない傾向がある。

【００２１】一方、高速走行時には速い操舵応答性が要求されるが、大きな操舵補助力は必要とされない。また、高速走行時にはステアリング系に発生する音や振動はロードノイズ等によってマスキングされるため、気にならない傾向にある。

【００２２】この発明はこのような課題を解決するためなされたもので、その目的は停車時や低速走行時でステアリング系の音や振動の発生を防止し、高速走行時の操舵応答性を速めて操舵フィーリングのよい電動パワーステアリング装置を提供することにある。

【００２３】

【課題を解決するための手段】前記課題を解決するため請求項１に係る電動パワーステアリング装置の制御手段は、車両の速度を検出する車速センサからの車速信号に基づいて比例要素の比例感度および積分要素の積分ゲインを低車速時よりも高車速時に大きく設定する比例・積分係数設定手段を備えたことを特徴とする。

【００２４】また、請求項２に係る電動パワーステアリング装置の制御手段は、偏差演算手段と比例・積分制御手段との間に、車両の速度を検出する車速センサからの車速信号に基づいて偏差信号を低車速時よりも高車速時に大きく設定する補正手段を備えたことを特徴とする。

【００２５】さらに、請求項３に係る電動パワーステアリング装置の制御手段は、車両の速度を検出する車速センサからの車速信号に基づいて目標電流信号および前記電動機電流信号をそれぞれ低車速時よりも高車速時に大きく設定する補正手段を備えたことを特徴とする。

【００２６】

【作用】請求項１に係る電動パワーステアリング装置は、制御手段に、車両の速度を検出する車速センサからの車速信号に基づいて比例要素の比例感度および積分要素の積分ゲインを低車速時よりも高車速時に大きく設定する比例・積分係数設定手段を備えたので、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができる。

【００２７】また、請求項２に係る電動パワーステアリング装置は、制御手段に、偏差演算手段と比例・積分制御手段との間に、車両の速度を検出する車速センサからの車速信号に基づいて偏差信号を低車速時よりも高車速時に大きく設定する補正手段を備えたので、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができる。

【００２８】さらに、請求項３に係る電動パワーステアリング装置は、制御手段に、車両の速度を検出する車速センサからの車速信号に基づいて目標電流信号および前記電動機電流信号をそれぞれ低車速時よりも高車速時に大きく設定する補正手段を備えたので、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができる。

【００２９】

【実施例】以下、この発明の実施例を添付図面に基づいて説明する。なお、本発明は、制御系のＰＩ（比例・積分）制御の比例感度および積分ゲインを車速の増加に伴って大きな値となるよう設定し、低速走行時に充分大き

な操舵補助力が得られ、高速走行時に応答が速い操舵特性が得られるようにするものである。

【００３０】図１はこの発明に係る電動パワーステアリング装置の全体構成図である。図１において、電動パワーステアリング装置１は、ステアリングホイール１７に一体的に設けられたステアリング軸２に自在継ぎ手３ａ、３ｂを備えた連結軸３を介し、ステアリング・ギアボックス４内に設けたラック＆ピニオン機構５のピニオン５ａに連結されて手動操舵力発生手段６を構成する。

【００３１】ピニオン５ａに噛み合うラック歯７ａを備え、これらの噛み合いにより往復運動するラック軸７は、その両端にタイロッド８を介して転動輪としての左右の前輪９が連結される。

【００３２】このようにして、ステアリングホイール１７操舵時には通常のラック＆ピニオン式の手動操舵力発生手段６を介し、マニュアルステアリングで前輪９を転動させて車両の向きを変えている。

【００３３】手動操舵力発生手段６による操舵力を軽減するため、操舵補助力を供給する電動機１０をラック軸７と同軸的に配設し、ラック軸７と同軸に設けられたボールねじ機構１１を介して推力に変換し、ラック軸７（ボールねじ軸１１ａ）に作用させる。

【００３４】ステアリング・ギアボックス４内にはドライバの手動操舵トルクの方向と大きさを検出する操舵トルクセンサ１２を配置し、操舵トルクセンサ１２が検出した操舵トルクに対応したアナログ電気信号の操舵トルク信号T_Sを制御手段１５に提供する。

【００３５】また、車速センサ１４は車両の速度に対応した周波数の電気的なパルス信号として検出し、車速信号V_Sを制御手段１５に提供する。

【００３６】制御手段１５はマイクロプロセッサを基本に各種演算手段、処理手段、信号発生手段、メモリ等で構成し、車速信号V_Sに応動した操舵トルク信号T_Sに対応する電動機制御信号V_0（例えば、オン信号とＰＷＭ信号の混成信号）を発生して電動機駆動手段１６を駆動制御する。

【００３７】また、制御手段１５は比例・積分制御手段、および車速信号V_Sが増加するに伴い増加する係数を発生する比例・積分係数設定手段を備え、比例・積分制御手段の比例要素の比例感度および積分要素の積分ゲインを比例・積分係数設定手段の係数で変更し、車速に適した操舵特性が得られるよう制御する。

【００３８】電動機駆動手段１６は、例えば４個のパワーＦＥＴ（電界効果トランジスタ）のスイッチング素子からなるブリッジ回路で構成し、電動機制御信号V_0に基づいて電動機電圧V_Mを出力して電動機１０を駆動する。

【００３９】電動機電流検出手段１８は電動機１０に実際に流れる電動機電流I_Mを検出し、電動機電流I_Mに対応した電動機電流信号I_{MO}を制御手段１５にフィードバック（負帰還）する。

【００４０】図２は請求項１に係る電動パワーステアリング装置の要部ブロック構成図である。図２において、制御手段１５は、目標電流設定手段２１、偏差演算手段２２、比例・積分制御手段２３、制御信号発生手段２７、比例・積分係数設定手段２８を備える。

【００４１】なお、目標電流設定手段２１、偏差演算手段２２および制御信号発生手段２７は、それぞれ図７に示す目標電流設定手段５２、偏差演算手段５３および制御信号発生手段５５と同一構成、同一作用なので説明を省略する。

【００４２】比例・積分制御手段２３は、比例感度K_Pを発生して比例制御する比例要素２４と、積分ゲインK_Iを発生して積分制御する積分要素２５と、比例要素２４および積分要素２５の出力信号を加算する加算器２６を備える。

【００４３】比例要素２４および積分要素２５は並列接続され、比例要素２４は偏差信号ΔIに比例感度K_Pを乗算した比例信号I_Pを、積分要素２５は偏差信号ΔIに積分ゲインK_Iを有する積分処理を施した積分信号I_Iを、それぞれ加算器２６に供給する。

【００４４】また、比例要素２４は比例・積分係数設定手段２８から供給される比例係数K_{VP}を比例感度K_Pに乗算する演算機能を備える。一方、積分要素２５は比例・積分係数設定手段２８から供給される積分係数K_{VI}を積分ゲインK_Iに乗算する演算機能を備える。

【００４５】加算器２６は比例信号I_Pと積分信号I_Iを加算し、比例・積分信号I_{PI}（$=I_P+I_I$）を制御信号発生手段２７に出力する。比例係数K_{VP}および積分係数K_{VI}を考慮した比例・積分信号I_{PI}は数２で表わされる。

【００４６】

【数２】

$$I_{PI}=K_P*K_{VP}*\Delta I+(K_I*K_{VI}/p)*\Delta I$$

【００４７】数２から明らかなように、比例係数K_{VP}を比例感度K_Pに乗算し、積分係数K_{VI}を積分ゲインK_Iに乗算することにより、比例感度K_Pおよび積分ゲインK_Iを変更することができる。また、比例係数K_{VP}および積分係数K_{VI}は車速信号V_Sに対応して変化するよう設定するので、比例・積分信号I_{PI}を車速応動の制御量とすることができる。

【００４８】比例・積分係数設定手段２８はＲＯＭ等のメモリで構成し、メモリ内に予め設計値や実験値から設定した車速信号V_Sと比例係数K_{VP}および積分係数K_{VI}の対応データを記憶しておき、車速センサ１４から車速信号V_Sが供給されると、メモリ内から車速信号V_Sに対応した比例係数K_{VP}および積分係数K_{VI}を読み出し、比例係数K_{VP}を比例要素２４に、積分係数K_{VI}を積分要素２５にそれぞれ供給する。

【００４９】車速信号V_Sに対応した比例係数K_{VP}と積

分係数K_{VI}は異なった値、または同じ値K_V（＝K_{VP}＝K_{VI}）のいずれにも設定することができる。

【００５０】図３に車速信号（V_S）—比例・積分係数（K_{VP}、K_{VI}）の特性図を示す。なお、比例係数K_{VP}と積分係数K_{VI}が等しい例を示す。図３の特性図において、車速信号V_Sが０（停車状態）の場合、例えば比例係数K_{VP}および積分係数K_{VI}を０．５に設定する。

【００５１】車速信号V_Sが低車速領域から増加すると比例係数K_{VP}および積分係数K_{VI}も０．５から次第に増加するよう設定し、高車速領域の所定値V_K（例えば、時速２０Ｋｍ）以上になると比例係数K_{VP}および積分係数K_{VI}が１．０となるよう設定する。

【００５２】このように、請求項１に係る電動パワーステアリング装置は、比例・積分係数設定手段を備え、低車速では小さい値、高車速では大きな値の比例係数K_{VP}および積分係数K_{VI}を出力し、比例・積分制御手段の比例感度K_Pおよび積分ゲインK_Iをそれぞれ比例係数K_{VP}および積分係数K_{VI}で制限するので、低車速走行時にはノイズに起因する音や振動の発生を防止し、高車速走行時には操舵応答性を速めることができる。

【００５３】図４は請求項２に係る電動パワーステアリング装置の要部ブロック構成図である。図４において、制御手段３０は、目標電流設定手段２１、偏差演算手段２２、補正手段３１、比例・積分制御手段３２、制御信号発生手段２７を備える。なお、制御手段３０は比例・積分係数設定手段２８に代えて補正手段３１を備えた点が図２に示す制御手段１５と基本的に異なる。

【００５４】なお、目標電流設定手段２１、偏差演算手段２２および制御信号発生手段２７は、それぞれ図７に示す目標電流設定手段５２、偏差演算手段５３および制御信号発生手段５５と同一構成、同一作用なので説明を省略する。

【００５５】補正手段３１はＲＯＭ等のメモリ、乗算機能を備え、予め設計値や実験値から設定した車速信号V_Sと補正係数H_Cの対応データを記憶しておき、車速センサ１４から供給される車速信号V_Sに対応した補正係数H_Cをメモリから読み出し、偏差信号ΔIに補正係数H_Cを乗算処理（$H_C * \Delta I$）し、補正偏差信号ΔI_C（＝$H_C * \Delta I$）を比例・積分制御手段３２に供給する。

【００５６】補正係数H_Cは、車速信号V_Sの増加に対応して増加するよう設定し、車両停止および低速走行時には補正偏差信号ΔI_Cを小さな値、高速走行時には補正偏差信号ΔI_Cを大きな値に設定する。

【００５７】なお、補正手段３１はフィードバック（負帰還）ループの偏差演算手段２２と比例・積分制御手段３２の間に設ける。

【００５８】補正手段３１から供給される補正偏差信号ΔI_Cは、比例・積分制御手段３２の比例要素３３、積分要素３４および加算器３５で数１に示す演算が施され、比例・積分信号I_{PI}は数３で表わされる。

【００５９】

【数３】

$$I_{PI} = K_P * \Delta I_C + (K_I / p) * \Delta I_C$$

$$= K_P * H_C * \Delta I + (K_I * H_C / p) * \Delta I$$

ただし、ｐはヘビサイド演算子

【００６０】数３は補正係数H_Cをそれぞれ比例係数K_{VP}および積分係数K_{VI}と等しく（$H_C = K_{VP}$、$H_C = K_{VI}$）すると、数２と同じくなり、補正係数H_Cを車速信号V_Sに対応して変化させることにより、低速走行時から高速走行時に亘って車速応動の操舵特性が得られるよう構成することができる。

【００６１】図５に車速信号（V_S）—補正係数（H_C）の特性図を示す。図５の特性図において、車速信号V_Sが０（停車状態）の場合、例えば補正係数H_Cを０．５に設定する。

【００６２】車速信号V_Sが低車速領域から増加すると補正係数H_Cも０．５から次第に増加するよう設定し、高車速領域の所定値V_K（例えば、時速２０Ｋｍ）以上になると補正係数H_Cが１．０となるよう設定する。

【００６３】図８に示すように、低車速領域（車速信号$V_S = V_L$）では目標電流信号I_{MS}が充分大きく、充分大きな電動機電流I_Mで電動機１０を駆動するため、充分な舵補助力をステアリング系に作用させることができる。

【００６４】また、低車速領域（車速信号$V_S = V_L$）では補正手段３１の補正係数H_Cを小さい値（$H_C = 0.5$）に設定して比例・積分制御手段３２を含む制御系の利得を小さく設定するため、操舵の応答性は遅くなるがノイズ等に起因する音や振動の発生を防止することができる。

【００６５】一方、高車速領域（車速信号$V_S = V_H$）では目標電流信号I_{MS}が小さく、小さな電動機電流I_Mで電動機１０を駆動し、舵補助力を小さく抑えて高速走行時の操舵の安定性を図る。

【００６６】また、高車速領域（車速信号$V_S = V_H$）では補正手段３１の補正係数H_Cを大きな値（$H_C = 1.0$）に設定して比例・積分制御手段３２を含む制御系の利得を大きく設定するため、操舵の応答を速くすることができる。

【００６７】請求項３に係る電動パワーステアリング装置は、図４に示す補正手段３１に代えて補正手段３１と同等な補正手段をそれぞれ目標電流設定手段２１と偏差演算手段２２間、電動機電流検出手段１８と偏差演算手段２２間に設け、目標電流信号I_{MS}および電動機電流信号I_{MO}をそれぞれ図５に示す補正係数H_C倍して偏差演算手段２２に供給するよう構成した点が図４に示す請求項３の制御手段３０と異なる。

【００６８】目標電流信号I_{MS}および電動機電流信号I_{MO}のそれぞれを補正係数H_C倍し、偏差信号ΔI（＝$H_C * I_{MS} - H_C * I_{MO}$）を図４の比例・積分制御手段３２

に供給するので、比例・積分信号I_{PI}は数３と同じくなり、図４の構成と同等の作用が得られる。

【００６９】図６にこの発明に係る電動パワーステアリング装置の操舵応答特性図を示す。図６において、操舵の応答性を電動機電流I_Mが目標電流信号I_{MS}に収束する応答時間t_Tで表わしたものである。

【００７０】図６に示すように、低車速領域（V_L）では電動機電流I_Mが目標電流信号I_{MS}に収束するまでの応答時間t_Tが長く操舵の応答が遅いが、高車速領域（V_H）では電動機電流I_Mが目標電流信号I_{MS}に収束するまでの応答時間t_Tが短く、操舵応答性がよいことを示す。

【００７１】

【発明の効果】以上説明したように、請求項１に係る電動パワーステアリング装置は、制御手段に、車両の速度を検出する車速センサからの車速信号に基づいて比例要素の比例感度および積分要素の積分ゲインを低車速時よりも高車速時に大きく設定する比例・積分係数設定手段を備え、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができるので、車両の走行状態に応じた最適の操舵フィーリングを得ることができる。

【００７２】また、請求項２に係る電動パワーステアリング装置は、制御手段に、偏差演算手段と比例・積分制御手段との間に、車両の速度を検出する車速センサからの車速信号に基づいて偏差信号を低車速時よりも高車速時に大きく設定する補正手段を備え、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができるので、車両の走行状態に応じた最適の操舵フィーリングを得ることができる。

【００７３】さらに、請求項３に係る電動パワーステアリング装置は、制御手段に、車両の速度を検出する車速センサからの車速信号に基づいて目標電流信号および前記電動機電流信号をそれぞれ低車速時よりも高車速時に大きく設定する補正手段を備えたので、低速走行時の音や振動を防止するとともに、高速走行時の操舵応答性を速くすることができるので、車両の走行状態に応じた最適の操舵フィーリングを得ることができる。

【００７４】よって、停車時や低速走行時のステアリング系に発生する音や振動を防止し、高速走行時の操舵応答性に優れた電動パワーステアリング装置を提供することができる。

【図面の簡単な説明】

【図１】この発明に係る電動パワーステアリング装置の全体構成図

【図２】請求項１に係る電動パワーステアリング装置の要部ブロック構成図

【図３】車速信号（V_S）―比例・積分係数（K_{VP}、K_{VI}）の特性図

【図４】請求項２に係る電動パワーステアリング装置の要部ブロック構成図

【図５】車速信号（V_S）―補正係数（H_C）の特性図

【図６】この発明に係る電動パワーステアリング装置の操舵応答特性図

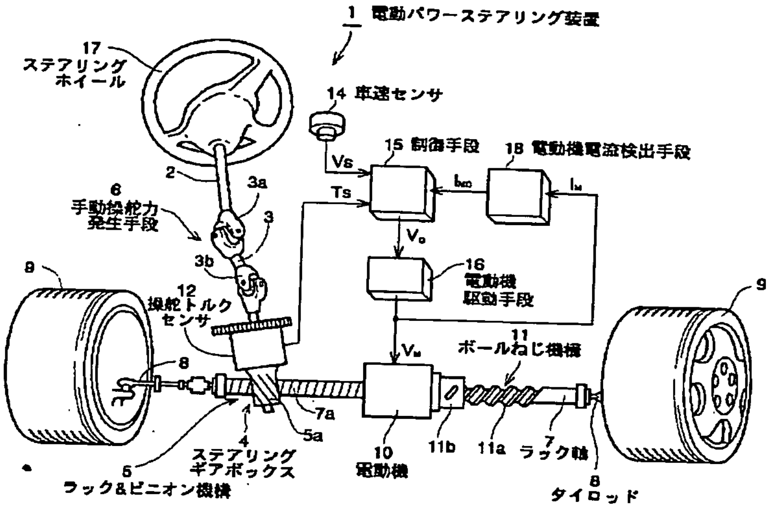
【図７】従来の電動パワーステアリング装置の要部ブロック構成図

【図８】車速をパラメータとした操舵トルク信号（T_D）―目標電流信号（I_{MS}）特性図（テーブル１）

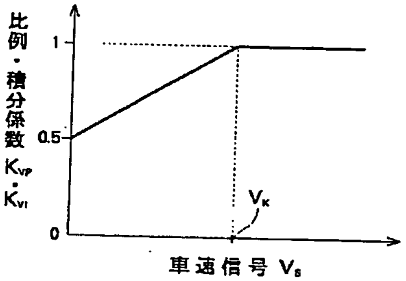
【符号の説明】

１…電動パワーステアリング装置、２…ステアリング軸、３…連結軸、３ａ，３ｂ…自在継ぎ手、４…ステアリング・ギアボックス、５…ラック＆ピニオン機構、５ａ…ピニオン、６…手動操舵力発生手段、７…ラック軸、７ａ…ラック歯、８…タイロッド、９…左右の前輪、１０…電動機、１１…ボールねじ機構、１２…操舵トルクセンサ、１４…車速センサ、１５，３０…制御手段、１６…電動機駆動手段、１７…ステアリングホイール、１８…電動機電流検出手段、２１…目標電流設定手段、２２…偏差演算手段、２３，３２…比例・積分制御手段、２４，３３…比例要素、２５，３４…積分要素、２６，３５…加算器、制御信号発生手段２７、２８…比例・積分係数設定手段、３１…補正手段、H_C…補正係数、I_I…積分信号、I_M…電動機電流、I_{MO}…電動機電流信号、I_{MS}…目標電流信号、I_P…比例信号、I_{PI}…比例・積分信号、ΔI（$=I_{MS}-I_{MO}$）…偏差信号、ΔI_C（$=H_C * \Delta I$）…補正偏差信号、K_I…積分ゲイン、K_P…比例感度、V_M…電動機電圧、V_0…電動機制御信号、V_{PWM}…ＰＷＭ信号、V_S（V_L．V_M．V_H）…車速信号。

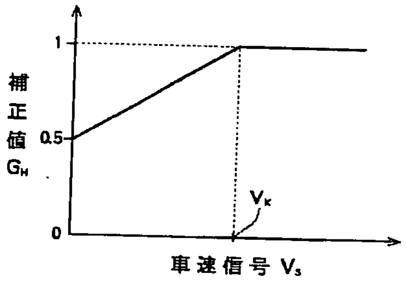
【図１】


1 電動パワーステアリング装置
17 ステアリングホイール
14 車速センサ
15 制御手段
18 電動機電流検出手段
Vs
Ts
I_{MO}
I_M
2
3a
6 手動操舵力発生手段
3
V_O
3b
16 電動機駆動手段
9
12 操舵トルクセンサ
9
V_M
11 ボールねじ機構
8
7a
5a
4 ステアリングギアボックス
5 ラック&ピニオン機構
10 電動機
11b
11a
7 ラック軸
8 タイロッド

【図３】


比例・積分係数 K_{VP}・K_{VI}
1
0.5
0
V_K
車速信号 V_S

【図５】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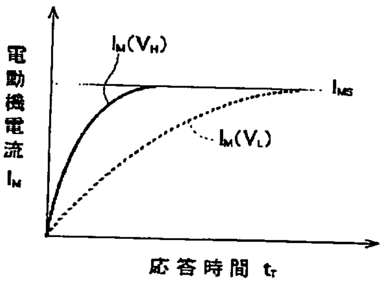
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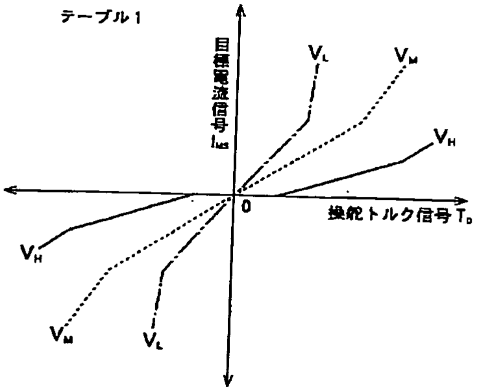
$I_M(V_H)$
I_{MS}
$I_M(V_L)$
応答時間 t_T

【図８】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V_L
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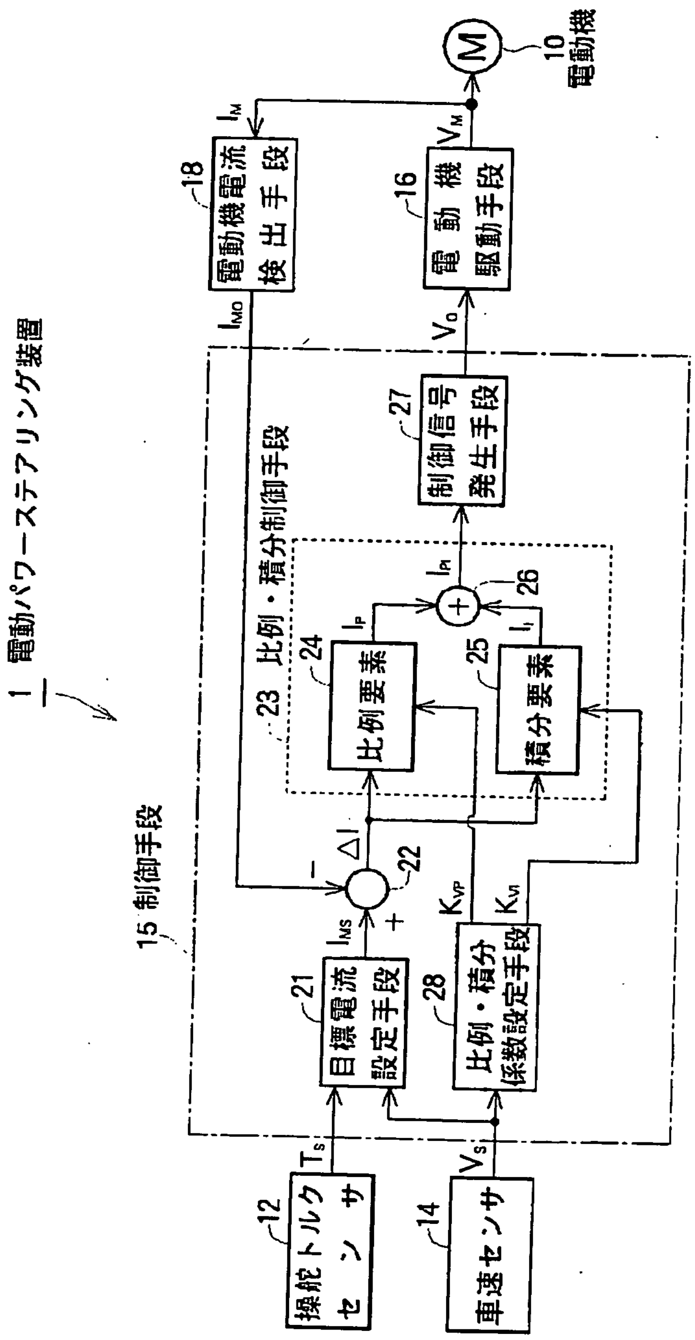
V_L

【図２】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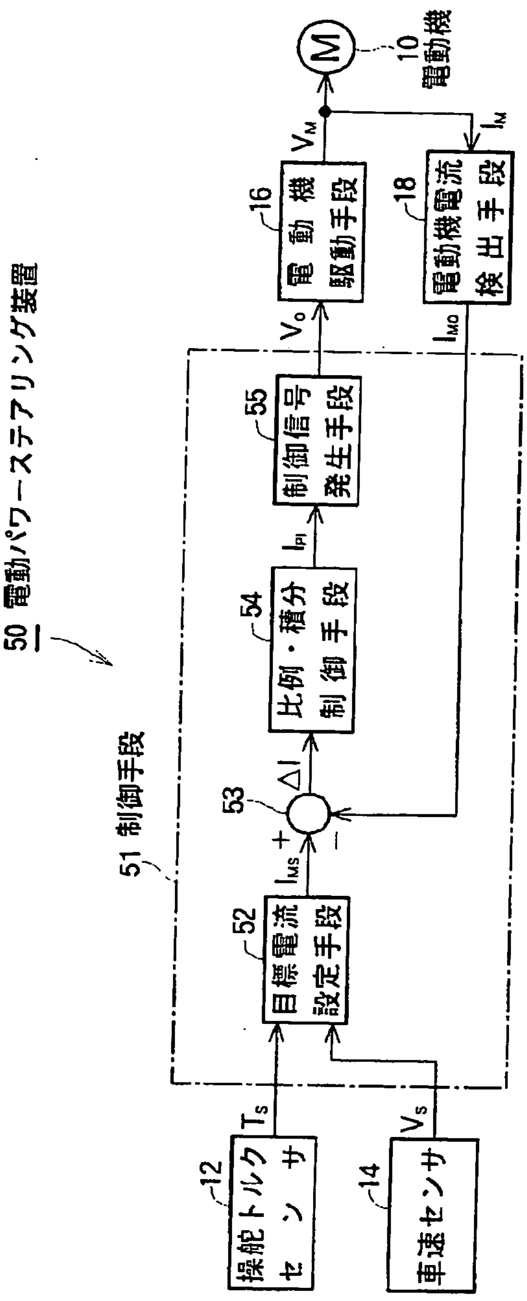
15 制御手段
12 操舵トルクセンサ
T_S
14 車速センサ
V_S
21 目標電流設定手段
I_{MS}
+
22
−
ΔI
28 比例・積分係数設定手段
K_{VP}
K_{VI}
23 比例・積分制御手段
24 比例要素
I_P
25 積分要素
I_I
26
I_{PI}
27 制御信号発生手段
V_O
16 電動機駆動手段
V_M
M
10 電動機
I_M
18 電動機電流検出手段
I_{MO}

【図７】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51 制御手段
12 操舵トルクセンサ
T_S
14 車速センサ
V_S
52 目標電流設定手段
I_{MS}
+
53
−
ΔI
54 比例・積分制御手段
I_{PI}
55 制御信号発生手段
V_O
16 電動機駆動手段
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M
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I_M
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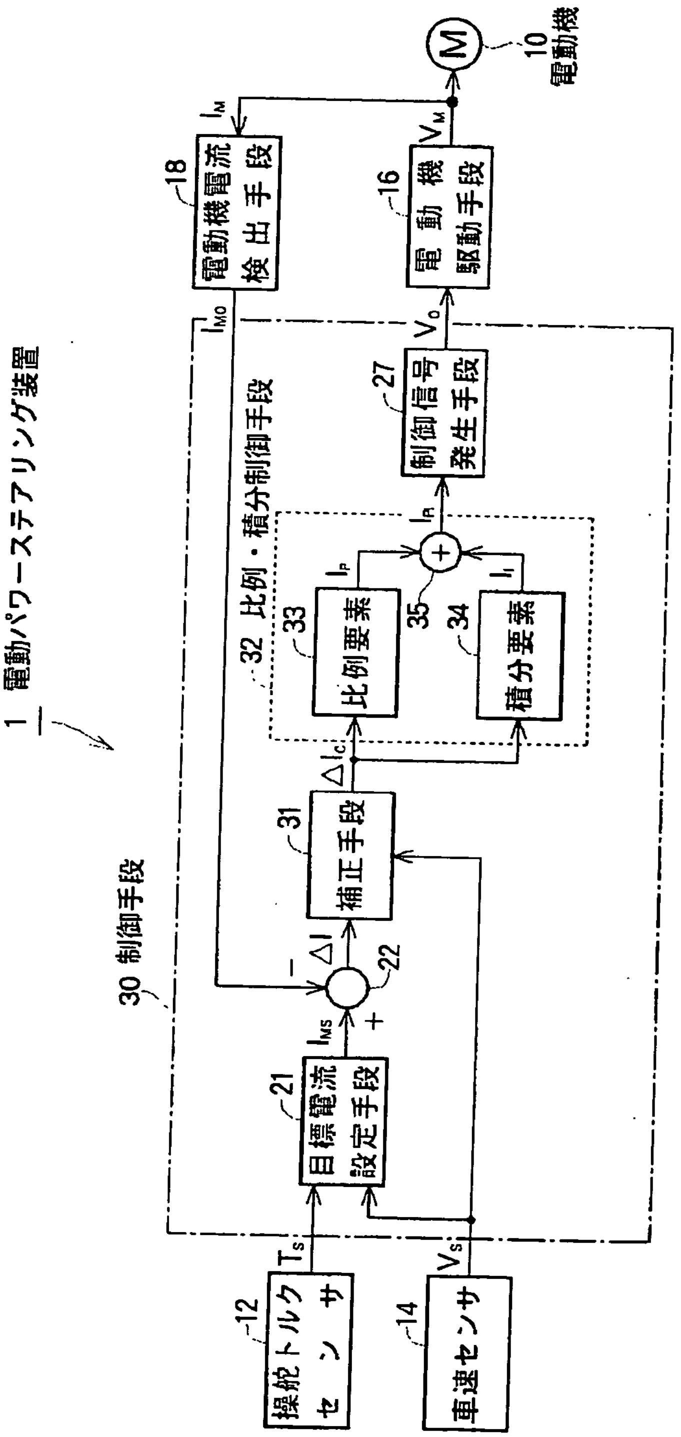
I_{MO}

【図４】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12 操舵トルクセンサ
14 車速センサ
T_S
V_S
30 制御手段
21 目標電流設定手段
I_{MS}
+
−
22
ΔI
31 補正手段
ΔI_C
32 比例・積分制御手段
33 比例要素
34 積分要素
35
I_P
I_I
I_R
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V_O
16 電動機駆動手段
V_M
18 電動機電流検出手段
I_M
I_{MO}
M
10 電動機

フロントページの続き

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特開　平５－238410（ＪＰ，Ａ）
特開　昭63－93679（ＪＰ，Ａ）
特開　平５－155352（ＪＰ，Ａ）
特開　平２－290773（ＪＰ，Ａ）
特開　平２－34460（ＪＰ，Ａ）
特開　平７－40844（ＪＰ，Ａ）

(58)調査した分野(Int.Cl.^{7}，ＤＢ名)
B62D　6/00
B62D　5/04

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B62D 5/04
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B62D119:00

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(72)Inventor : MUKAI YOSHINOBU
HIRONAKA SHINJI
NORO EIKI

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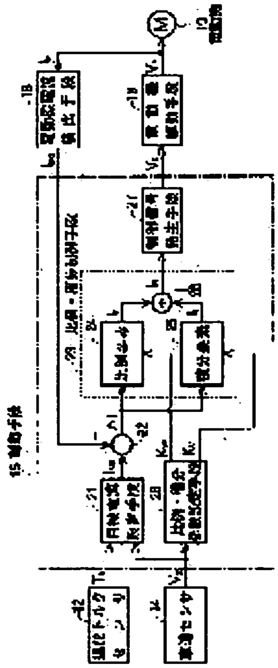
(54) MOTOR-DRIVEN POWER STEERING SYSTEM

(57)Abstract:
PURPOSE: To provide a motor-driven power steering system preventing sound and vibration generated in a steering system during the stop of a vehicle and during low speed travel while being excellent in steering responsiveness during high speed travel.
CONSTITUTION: A motor-driven power steering is provided with a control means 15 consisting of a target current setting means 21, a deviation computing means 22, a proportional-plus-integral control means 23 provided with a proportional element 24, an integral element 25 and an adder 26, and a control signal generating means 27.



LEGAL STATUS

[Date of request for examination]	27.10.1998
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3152339
[Date of registration]	26.01.2001
[Number of appeal against examiner's decision of rejection]	

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

[Claim(s)]

[Claim 1] The steering torque sensor which detects the steering torque of a steering system, and the motor which makes the steering auxiliary force act on a steering system, A target current setting means to determine the target current signal which drives said motor based on the steering torque signal from said steering torque sensor, And the control means which consists of proportionality and an integral control means which controlled said motor based on the deflection of the target current signal from this target current setting means, and the motor current signal from a motor current detection means, and was equipped with the proportional element and the integral element at least, In ******** electromotive power-steering equipment said control means Electric power-steering equipment characterized by having a proportionality / integral multiplier setting means to set up greatly the proportional sensitivity of said proportional element, and the integral gain of said integral element rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed.

[Claim 2] The steering torque sensor which detects the steering torque of a steering system, and the motor which makes the steering auxiliary force act on a steering system, A target current setting means to determine the target current signal which drives said motor based on the steering torque signal from said steering torque sensor, A deflection operation means to calculate the deflection of the target current signal from this target current setting means, and the motor current signal from a motor current detection means, and to output a deflection signal, In electromotive power-steering equipment equipped with the control means which consists of proportionality and an integral control means which controlled said motor based on said deflection signal, and was equipped with the proportional element and the integral element at least Said control means is electric power-steering equipment characterized by having an amendment means to set up said deflection signal greatly rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed between said deflection operation means, and said proportionality and integral control means.

[Claim 3] The steering torque sensor which detects the steering torque of a steering system, and the motor which makes the steering auxiliary force act on a steering system, A target current setting means to determine the target current signal which drives said motor based on the steering torque signal from said steering torque sensor, A deflection operation means to calculate the deflection of the target current signal from this target current setting means, and the motor current signal from a motor current detection means, and to output a deflection signal, In electromotive power-steering equipment equipped with the control means which consists of proportionality and an integral control means which controlled said motor based on said deflection signal, and was equipped with the proportional element and the integral element at least Said control means is electric power-steering equipment characterized by having an amendment means to set up greatly said target current signal and said motor current signal rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed, respectively.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is made to act on a steering system by making power of a motor into the steering auxiliary force, and relates to the electric power-steering equipment which mitigates the control force of a driver, especially prevents the sound of a steering system, and generating of vibration in the low vehicle speed field of a car, and relates to the electric power-steering equipment which improves control-response nature of a steering system in the high vehicle speed field of a car.

[0002]

[Description of the Prior Art] In conventional electric power-steering equipment, the steering torque generated with handle actuation of a driver is detected by the steering torque sensor. The detected steering torque signal is changed into the target current signal which drives a motor. The signal which performed PI (proportionality and integral) or PID (proportionality, integral, and differential) control to the deflection signal of a target current signal and the motor current signal corresponding to the motor current which actually flows to a motor is generated. The thing drive [thing] a motor with the motor control signal (for example, PWM signal) generated based on this signal, and it was made to make the steering auxiliary force act on a steering system is known.

[0003] Such conventional electric power-steering equipment is controlled so that a motor current signal is made to feed back to a target current signal (negative feedback) and a deflection signal is promptly set to 0 for PI or the configuration which carries out PID control, a motor current is converged on the value set up with the target current signal, a motor is driven, and the steering auxiliary force corresponding to a steering torque signal is acquired.

[0004] The important section block block diagram of conventional electric power-steering equipment is shown in drawing 7 . In addition, drawing 7 shows the example which performed PI (proportionality and integral) control to the control system. In drawing 7 , electric power-steering equipment 50 consists of the steering torque sensor 12, a speed sensor 14, a control means 51, a motor driving means 16, a motor current detection means 18, and a motor 10.

[0005] A control means 51 consists of various operation means, a comparison / processing means, memory, etc. on the basis of a microprocessor, and is equipped with the target current setting means 52, the deflection operation means 53, proportionality and an integral control means 54, and the control signal generating means 55.

[0006] The steering torque sensor 12 detects the steering torque corresponding to handle actuation of a driver as an electrical signal of an analog, and the steering torque signal TS is supplied to the target current setting means 52. A speed sensor 14 is detected as an electric pulse signal of the frequency corresponding to the rate of a car, and a vehicle speed signal VS is supplied to the target current setting means 52.

[0007] A target current setting means 52 changes into a digital steering torque signal TD the steering torque signal TS supplied from the steering torque sensor 12, changes it into this steering torque signal TD and the target current signal IMS beforehand set up based on the vehicle speed signal VS supplied from a speed sensor 14, and it is constituted so that the target current signal IMS over the steering torque signal TD which made the parameter the vehicle speed VS (VL, VM, VH) may output to a deflection operation means 53.

[0008] The steering torque (signal TD)-target current signal (IMS) property Fig. (table 1) which made the vehicle speed the parameter at drawing 8 is shown. In drawing 8 , the vehicle speed VL, VM, and VH shows a low vehicle speed field, an inside vehicle speed field, and a high vehicle speed field, respectively, and even if the steering torque signal TD is the same, the vehicle speed VS follows on increasing (VL->VM->VH), and the target current signal IMS is beforehand set up so that it may decrease.

[0009] Thus, in a low vehicle speed field (VS=VL), a motor 10 is driven with the big motor current IM corresponding to the target current signal IMS, the sufficiently big steering auxiliary force is acquired, and the target current setting means 52 drives a motor 10 with the small motor current IM corresponding to the target current signal IMS, suppresses the steering auxiliary force, and on the other hand, it consists of high vehicle speed fields (VS=VH) so that the stability of steering may be acquired.

[0010] The deflection operation means 53 is detected by the target current signal IMS and the motor current detection means 18, the deflection (= IMS-IMO) of the motor current signal IMO which was made to correspond to the motor current IM and was changed into the digital signal is calculated, and proportionality and the integral control means 54 are provided with deflection signal deltaI.

[0011] Proportionality and the integral control means 54 carry out parallel connection of the proportional element which doubles deflection signal deltaI proportional sensitivity KP, and the integral element which carries out integral control of the deflection signal deltaI (=IMS-IMO) by the integral gain KI, and is constituted, proportionality and an integration operator are performed to deflection signal deltaI, and proportionality / integral signal IPI is supplied to the control signal generating means 55. Proportionality / integral signal IPI is expressed with several 1 using proportional sensitivity KP and the integral gain KI.

[0012]

[Equation 1] IPI=KP*deltaI+(KI/p) *deltaI, however p are a Heaviside operator [0013]. In addition, the motor current signal IMO (it corresponds to the motor current IM) can be promptly completed as the target current signal IMS by setting up greatly the value of proportional sensitivity KP and the integral gain KI (deflection signal deltaI=0).

[0014] It has an PWM (Pulse Density Modulation) signal generation means, the PWM signal VPWM corresponding to the magnitude and the direction of proportionality / integral signal IPI is supplied to the motor driving means 16 as a motor control signal VO, and a motor 10 drives the control signal generating means 55 on the motor electrical potential difference VM from the motor driving means 16.

[0015] Moreover, although a motor 10 drives with the motor control signal VO and the motor current IM flows, the motor current signal IMO with which the motor current detection means 18 detected the motor current IM, and corresponded returns to the deflection operation means 53.

[0016] Thus, since conventional electric power-steering equipment 50 was constituted so that the motor current IM might be made to feed back ******** to the target current signal IMS (negative feedback) and proportionality and integral control might be performed to deflection signal deltaI, the motor current signal IMO is promptly completed as the target current signal IMS, the motor power corresponding to steering torque is obtained, and it becomes possible to make the steering auxiliary force of a good request of responsibility act on a steering system of it.

[0017]

[Problem(s) to be Solved by the Invention] Since the proportional sensitivity KP of proportionality and the integral control means 54 and the value of the integral gain KI are set as constant value to the vehicle speed, in the case where it runs in the case where a car runs in the low vehicle speed field VL, and the high vehicle speed field VH, car behavior differs and conventional electric power-steering equipment 50 has the following technical problems.

[0018] Since the target current signal IMS is set as the large value as shown in drawing 8 R> 8 when a car runs in the low vehicle speed field VL, when proportional sensitivity KP and integral gain KI are enlarged, the technical problem which the sound which the gain of a control means 51 becomes high beyond the need, and originates in a steering system at a noise etc., and vibration generate occurs.

[0019] Moreover, when a car runs in the high vehicle speed field VH and proportional sensitivity KP and integral gain KI are made small since the target current signal IMS is set as the small value, delay is produced in the response of a control means 51, after carrying out handle actuation before a wheel steers, there is a time lag, and the technical problem to which control-response nature falls occurs.

[0020] Generally, while the steering auxiliary force at the time of a stop and low-speed transit in which a steering property is big is required, reduction of the sound generated in a steering system or vibration is required. However, about the control-response nature at the time of a stop and low-speed transit, there is an inclination which is not somewhat worrisome at the latest.

[0021] On the other hand, although quick control-response nature is required at the time of high-speed transit, the big steering auxiliary force is not needed. Moreover, since the sound and vibration which are generated in a steering system at the time of high-speed transit are masked by load NOISU etc., they are in the inclination which is not worried.

[0022] It is in having been made in order that this invention might solve such a technical problem, being that purpose at the stop and low-speed transit time, it preventing the sound of a steering system, and generating of vibration, speeding up the control-response nature at the time of high-speed transit, and offering the good electric power-steering equipment of a steering feeling.

[0023]

[Means for Solving the Problem] The control means of the electric power-steering equipment applied to claim 1 in order to solve said technical problem is characterized by having a proportionality / integral multiplier setting means to set up greatly the proportional sensitivity of a proportional element, and the integral gain of an integral element rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed.

[0024] Moreover, the control means of the electric power-steering equipment concerning claim 2 is characterized by having an amendment means to set up a deflection signal greatly rather than the time of the low vehicle speed between a deflection operation means, and proportionality and an integral control means based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed.

[0025] Furthermore, the control means of the electric power-steering equipment concerning claim 3 is characterized by having an amendment means to set up greatly a target current signal and said motor current signal rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed, respectively.

[0026]

[Function] It can make quick control-response nature at the time of high-speed transit while it prevents the sound at the time of low-speed transit, and vibration, since the electric power-steering equipment concerning claim 1 was equipped with a proportionality / integral multiplier setting means to set greatly the proportional sensitivity of a proportional element, and the integral gain of an integral element as a control means rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed.

[0027] Moreover, it can make quick control-response nature at the time of high-speed transit while it prevents the sound at the time of low-speed transit, and vibration, since the electric power-steering equipment concerning claim 2 was equipped with an amendment means set a deflection signal as a control means greatly rather than the time of the low vehicle speed between a deflection operation means, and proportionality and an integral control means based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed.

[0028] Furthermore, it can make quick control-response nature at the time of high-speed transit while it prevents the sound at the time of low-speed transit, and vibration, since the electric power-steering equipment concerning claim 3 was equipped with an amendment means to set greatly a target current signal and said motor current signal as a control means rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed, respectively.

[0029]

[Example] Hereafter, the example of this invention is explained based on an accompanying drawing. In addition, this invention is set up so that it may become a big value at the increment in the vehicle speed with the proportional sensitivity and integral gain of PI (proportionality and integral) control of a control system, the sufficiently big steering auxiliary force is acquired at the time of low-speed transit, and the steering property that a response is quick is acquired at the time of high-speed transit.

[0030] Drawing 1 is the whole electric power-steering equipment block diagram concerning this invention. In drawing 1 , electric power-steering equipment 1 is connected with pinion 5a of the rack & pinion device 5 established in the steering gearbox 4 through the connecting shaft 3 which equipped with universal joints 3a and 3b the steering shaft 2 prepared in the steering wheel 17 in one, and constitutes the manual control-force generating means 6.

[0031] It has rack gear-tooth 7a which gears to pinion 5a, and, as for the rack shaft 7 which reciprocates by these engagement, the front wheel 9 on either side as a rolling ring is connected with the both ends through a tie rod 8.

[0032] Thus, at the time of steering wheel 17 steering, a front wheel 9 is rolled with a manual steering through the manual control-force generating means 6 of the usual rack-and-pinion type, and the sense of a car is changed.

[0033] In order to mitigate the control force by the manual control-force generating means 6, the motor 10 which supplies the steering auxiliary force is arranged in same axle with the rack shaft 7, is changed into a thrust through the ball-thread device 11 prepared in the rack shaft 7 and the same axle, and is made to act on the rack shaft 7 (ball-thread shaft 11a).

[0034] In the steering gearbox 4, the steering torque sensor 12 which detects the direction and magnitude of manual steering torque of a driver is arranged, and a control means 15 is provided with the steering torque signal TS of the analog electrical signal corresponding to the steering torque which the steering torque sensor 12 detected.

[0035] Moreover, a speed sensor 14 is detected as an electric pulse signal of the frequency corresponding to the rate of a car, and provides a control means 15 with a vehicle speed signal VS.

[0036] A control means 15 is constituted from various operation means, a processing means, a signal generation means, memory, etc. on the basis of a microprocessor, generates the motor control signal VO (for example, hybrid signal of an ON signal and an PWM signal) corresponding to the steering torque signal TS following a vehicle speed signal VS, and carries out drive control of the motor driving means 16.

[0037] Moreover, a control means 15 is equipped with proportionality, an integral control means, and a proportionality / integral multiplier setting means to generate the multiplier which a vehicle speed signal VS follows on increasing, and increases, changes the proportional sensitivity of the proportional element of proportionality and an integral control means, and the integral gain of an integral element by the multiplier of proportionality / integral multiplier setting means, and it controls them so that the steering property suitable for the vehicle speed is acquired.

[0038] The motor driving means 16 is constituted from a bridge circuit which consists of a switching element of four power FET (field-effect transistor), outputs the motor electrical potential difference VM based on the motor control signal VO, and drives a motor 10.

[0039] The motor current detection means 18 detects the motor current IM which actually flows to a motor 10, and feeds back the motor current signal IMO corresponding to the motor current IM to a control means 15 (negative feedback).

[0040] Drawing 2 is the important section block block diagram of the electric power-steering equipment concerning claim 1. A control means 15 is equipped with the target current setting means 21, the deflection operation means 22, proportionality and an integral control means 23, the control signal generating means 27, and proportionality / integral multiplier setting means 28 in drawing 2 .

[0041] In addition, since the target current setting means 21, the deflection operation means 22, and the control signal generating means 27 are the same configuration as the target current setting means 52, the deflection operation means 53, and the control signal generating means 55 which are shown in drawing 7 , respectively, and the same operation, they omit explanation.

[0042] Proportionality and the integral control means 23 are equipped with the adder 26 adding the output signal of the proportional element 24 which generates and carries out proportional control of the proportional sensitivity KP, the integral element 25 which generates and carries out integral control of the integral gain KI, and a proportional element 24 and an integral element 25.

[0043] Parallel connection of a proportional element 24 and the integral element 25 is carried out, and a proportional element 24 supplies the integral signal II which performed integral processing to which an integral element 25 has the integral gain KI for the proportionality signal IP which carried out the multiplication of the proportional sensitivity KP to deflection signal deltaI in deflection signal deltaI to an adder 26, respectively.

[0044] Moreover, a proportional element 24 is equipped with the calculation function which carries out the multiplication of the proportionality coefficient KVP supplied from proportionality / integral multiplier setting means 28 to proportional sensitivity KP. On the other hand, an integral element 25 is equipped with the calculation function which carries out the multiplication of the integral multiplier KVI supplied from proportionality / integral multiplier setting means 28 to the integral gain KI.

[0045] An adder 26 adds the proportionality signal IP and the integral signal II, and outputs proportionality / integral signal IPI (=IP+II) to the control signal generating means 27. Proportionality / integral signal IPI in consideration of a proportionality coefficient KVP and the integral multiplier KVI is expressed with several 2.

[0046]

[Equation 2]

IPI=KP*KVP*deltaI+(KI*KVI/p) *deltaI [0047] Proportional sensitivity KP and the integral gain KI can be changed by carrying out the multiplication of the proportionality coefficient KVP to proportional sensitivity KP, and carrying out the multiplication of the integral multiplier KVI to the integral gain KI so that clearly from several 2. Moreover, since a proportionality coefficient KVP and the integral multiplier KVI are set up so that it may change corresponding to a vehicle speed signal VS, proportionality / integral signal IPI can be made into the controlled variable of a vehicle speed corresponding movement.

[0048] It will be constituted from memory, such as ROM, and if a vehicle speed signal VS is supplied from a speed sensor 14, the associated data of the vehicle speed signal VS beforehand set up from the design value or the experimental value in memory, a proportionality coefficient KVP, and the integral multiplier KVI will be memorized, proportionality / integral multiplier setting means 28 reads the proportionality coefficient KVP and the integral multiplier KVI corresponding to a vehicle speed signal VS from the inside of memory, and a proportionality coefficient KVP will be supplied to a proportional element 24, and it will supply the integral multiplier KVI to an integral element 25, respectively.

[0049] The proportionality coefficient KVP and the integral multiplier KVI corresponding to a vehicle speed signal VS can be set to either a different value or the same value KV (=KVP=KVI).

[0050] The property Fig. of (vehicle speed signal VS)-proportionality / integral multiplier (KVP, KVI) is shown in drawing 3 . In addition, an example with equal proportionality coefficient KVP and integral multiplier KVI is shown. In the property Fig. of drawing 3 , when a vehicle speed signal VS is 0 (stop condition), a proportionality coefficient KVP and the integral multiplier KVI are set as 0.5.

[0051] If a vehicle speed signal VS increases from a low vehicle speed field, it will set up so that a proportionality coefficient KVP and the integral multiplier KVI may also increase from 0.5 gradually, and if it becomes beyond the predetermined value VK of a high vehicle speed field (for example, 20km/h), it will set up so that a proportionality coefficient KVP and the integral multiplier KVI may be set to 1.0.

[0052] Thus, the electric power-steering equipment concerning claim 1 Have proportionality / integral multiplier setting means, and the proportionality coefficient KVP and the integral multiplier KVI of a big value are outputted with a small value and the high vehicle speed with the low vehicle speed. Since the proportional sensitivity KP and the integral gain KI of proportionality and an integral control means are restricted by the proportionality coefficient KVP and the integral multiplier KVI, respectively, at the time of low vehicle speed transit, generating of the sound resulting from a noise or vibration can be prevented, and control-response nature can be sped up at the time of high vehicle speed transit.

[0053] Drawing 4 is the important section block block diagram of the electric power-steering equipment concerning claim 2. A control means 30 is equipped with the target current setting means 21, the deflection operation means 22, the amendment means 31, proportionality and an integral control means 32, and the control signal generating means 27 in drawing 4 . In addition, the point which replaced the control means 30 with proportionality / integral multiplier setting means 28, and was equipped with the amendment means 31 differs from the control means 15 shown in drawing 2 fundamentally.

[0054] In addition, since the target current setting means 21, the deflection operation means 22, and the control signal generating means 27 are the same configuration as the target current setting means 52, the deflection operation means 53, and the control signal generating means 55 which are shown in drawing 7 , respectively, and the same operation, they omit explanation.

[0055] The amendment means 31 is equipped with memory, such as ROM, and a multiplication function, memorizes the associated data of the vehicle speed signal VS beforehand set up from the design value or the experimental value, and a correction factor HC, reads the correction factor HC corresponding to the vehicle speed signal VS supplied from a speed sensor 14 from memory, carries out multiplication processing (HC*deltaI) of the correction factor HC to deflection signal deltaI, and supplies amendment deflection signal deltaIC (=HC*deltaI) to proportionality and the integral-control means 32.

[0056] A correction factor HC is set up so that it may increase corresponding to the increment in a vehicle speed signal VS, and it sets amendment deflection signal deltaIC as a big value for amendment deflection signal deltaIC at the time of a small value and high-speed transit at the time of a car halt and low-speed transit.

[0057] In addition, the amendment means 31 is established between the deflection operation means 22 of a feedback (negative feedback) loop formation, and proportionality and an integral control means 32.

[0058] The operation which shows amendment deflection signal deltaIC supplied from the amendment means 31 to several 1 with the proportional element 33, the integral element 34, and adder 35 of proportionality and the integral control means 32 is performed, and proportionality / integral signal IPI is expressed with several 3.

[0059]

[Equation 3]

IPI=KP*deltaIC+(KI/p) *deltaIC=KP*HC*deltaI+(KI*HC/p) *deltaI, however p are a Heaviside operator [0060]. If a correction factor HC is made equal (HC=KVP, HC=KVI) to a proportionality coefficient KVP and the integral multiplier KVI, respectively, several 3 becomes the same with several 2, and it can be constituted by changing a correction factor HC corresponding to a vehicle speed signal VS so that the steering property of a vehicle speed corresponding movement may be acquired ranging from the time of low-speed transit to the time of high-speed transit.

[0061] The property Fig. of a (vehicle speed signal VS)-correction factor (HC) is shown in drawing 5 . In the property Fig. of drawing 5 , when a vehicle speed signal VS is 0 (stop condition), a correction factor HC is set as 0.5.

[0062] If a vehicle speed signal VS increases from a low vehicle speed field, it will set up so that a correction factor HC may increase from 0.5 gradually, and if it becomes beyond the predetermined value VK of a high vehicle speed field (for example, 20km/h), it will set up so that a correction factor HC may be set to 1.0.

[0063] Since the target current signal IMS is large enough and drives a motor 10 with the sufficiently big motor current IM, sufficient rudder auxiliary force can be made to act on a steering system in a low vehicle speed field (vehicle speed signal VS=VL), as shown in drawing 8 .

[0064] Moreover, in a low vehicle speed field (vehicle speed signal VS=VL), since the gain of the control system which sets the correction factor HC of the amendment means 31 as a small value (HC=0.5), and includes proportionality and the integral control means 32 is set up small, although the responsibility of steering becomes late, it can prevent generating of the sound resulting from a noise etc., or vibration.

[0065] On the other hand, in a high vehicle speed field (vehicle speed signal VS=VH), the target current signal IMS is small, drives a motor 10 with the small motor current IM, suppresses the rudder auxiliary force small, and plans stability of steering at the time of high-speed transit.

[0066] Moreover, in a high vehicle speed field (vehicle speed signal VS=VH), since the gain of the control system which sets the correction factor HC of the amendment means 31 as a big value (HC=1.0), and includes proportionality and the integral control means

32 is set up greatly, the response of steering can be made quick.

[0067] the correction factor HC twice which replaces the electric power-steering equipment concerning claim 3 with the amendment means 31 shown in drawing 4 , establishes an amendment means equivalent to an amendment means 31 between a target current setting means 21, between deflection operation means 22 and a motor current detection means 18, and a deflection operation means 22 respectively, and shows a target current signal IMS and a motor current signal IMO to drawing 5 respectively -- the point which constituted so that it carries out and a deflection operation means 22 supplies differs from the control means 30 of a claim 3 which shows in drawing 4 .

[0068] each of the target current signal IMS and the motor current signal IMO -- correction factor HC twice -- since it carries out and deflection signal deltaI (=HC*IMS-HC*IMO) is supplied to proportionality and the integral control means 32 of drawing 4 , proportionality / integral signal IPI becomes the same with several 3, and an operation equivalent to the configuration of drawing 4 is acquired.

[0069] The control-response property Fig. of the electric power-steering equipment applied to this invention at drawing 6 is shown. The responsibility of steering is expressed with the response time tT which the motor current IM converges on the target current signal IMS in drawing 6 .

[0070] Although the response time tT until it is completed as the target current signal IMS by the motor current IM is long and the response of steering is slow in a low vehicle speed field (VL) as shown in drawing 6 , a high vehicle speed field (VH) shows that the response time tT until it is completed as the target current signal IMS by the motor current IM is short, and control-response nature is good.

[0071]

[Effect of the Invention] As explained above, the electric power-steering equipment concerning claim 1 It has a proportionality / integral multiplier setting means to set greatly the proportional sensitivity of a proportional element, and the integral gain of an integral element as a control means rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed. Since control-response nature at the time of high-speed transit can be made quick while preventing the sound at the time of low-speed transit, and vibration, the optimal steering feeling according to the run state of a car can be obtained.

[0072] Moreover, the electric power-steering equipment concerning claim 2 It has an amendment means to set a deflection signal as a control means greatly rather than the time of the low vehicle speed between a deflection operation means, and proportionality and an integral control means based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed. Since control-response nature at the time of high-speed transit can be made quick while preventing the sound at the time of low-speed transit, and vibration, the optimal steering feeling according to the run state of a car can be obtained.

[0073] Furthermore, the electric power-steering equipment concerning claim 3 Since it had an amendment means to set greatly a target current signal and said motor current signal as a control means rather than the time of the low vehicle speed based on the vehicle speed signal from the speed sensor which detects the rate of a car at the time of the high vehicle speed, respectively Since control-response nature at the time of high-speed transit can be made quick while preventing the sound at the time of low-speed transit, and vibration, the optimal steering feeling according to the run state of a car can be obtained.

[0074] Therefore, the sound and vibration which are generated in the steering system at the time of a stop and low-speed transit can be prevented, and electric power-steering equipment excellent in the control-response nature at the time of high-speed transit can be offered.

[Brief Description of the Drawings]

[Drawing 1] The whole electric power-steering equipment block diagram concerning this invention

[Drawing 2] The important section block block diagram of the electric power-steering equipment concerning claim 1

[Drawing 3] The property Fig. of (vehicle speed signal VS)-proportionality / integral multiplier (KVP, KVI)

[Drawing 4] The important section block block diagram of the electric power-steering equipment concerning claim 2

[Drawing 5] The property Fig. of a (vehicle speed signal VS)-correction factor (HC)

[Drawing 6] The control-response property Fig. of the electric power-steering equipment concerning this invention

[Drawing 7] The important section block block diagram of conventional electric power-steering equipment

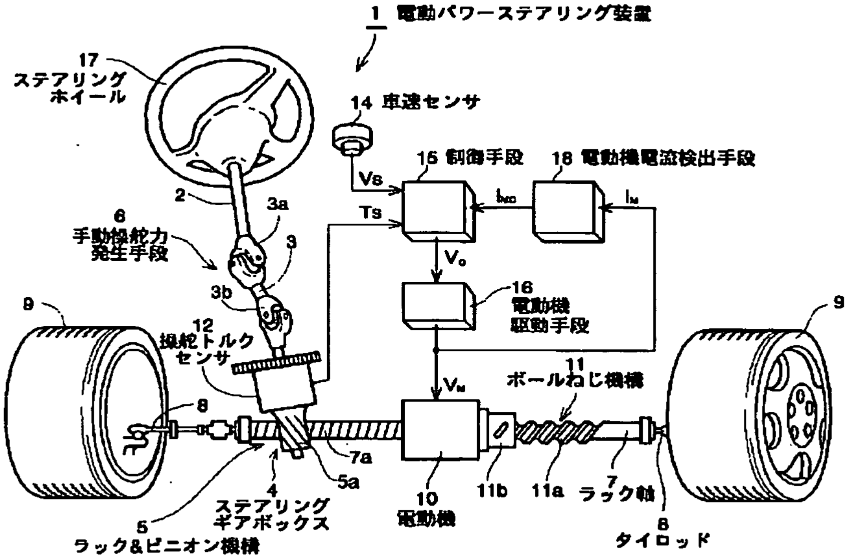
[Drawing 8] The steering torque (signal TD)-target current signal (IMS) property Fig. which made the vehicle speed the parameter (table 1)

[Description of Notations]

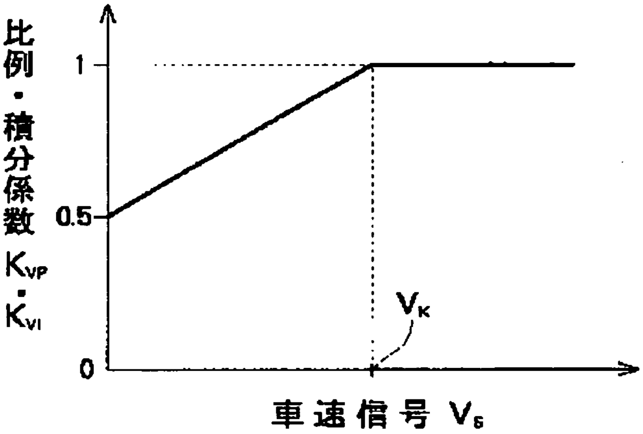
1 -- Electric power-steering equipment, 2 -- A steering shaft, 3 -- Connecting shaft, 3a, 3b -- A universal joint, 4 -- A steering gearbox, 5 -- Rack & pinion device, 5a [-- Rack gear

tooth,] -- A pinion, 6 -- A manual control-force generating means, 7 -- A rack shaft, 7a 8 [-- Ball-thread device,] -- A tie rod, 9 -- A front wheel on either side, 10 -- A motor, 11 12 -- A steering torque sensor, 14 -- 15 A speed sensor, 30 -- Control means, 16 -- A motor driving means, 17 -- A steering wheel, 18 -- Motor current detection means, 21 -- A target current setting means, 22 -- 23 A deflection operation means, 32 -- Proportionality and an integral control means, 24 33 -- 25 A proportional element, 34 -- 26 An integral element, 35 -- Adder, Control signal generating means 27 and 28 -- Proportionality / integral multiplier setting means, 31 -- Amendment means, HC [-- Motor current signal,] -- A correction factor, II -- An integral signal, IM -- A motor current, IMO IMS -- A target current signal, IP -- A proportionality signal, IPI -- Proportionality / integral signal, deltaI [-- Proportional sensitivity, VM / -- A motor electrical potential difference, VO / -- A motor control signal, a VPWM--PWM signal, VS (VL VM, VH) / -- Vehicle speed signal.] (=IMS-IMO) -- A deflection signal, deltaIC (=HC*deltaI) -- An amendment deflection signal, KI -- Integral gain, KP

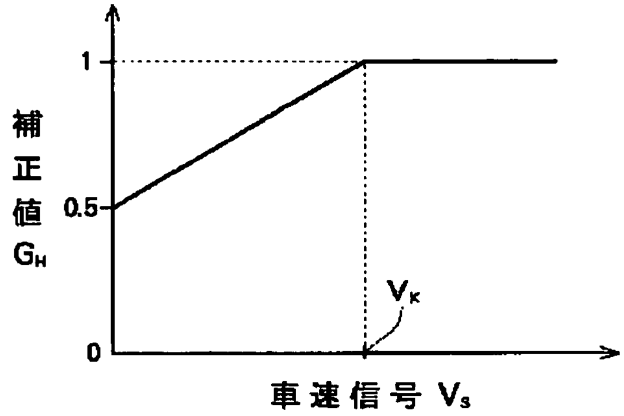
[Drawing 1]



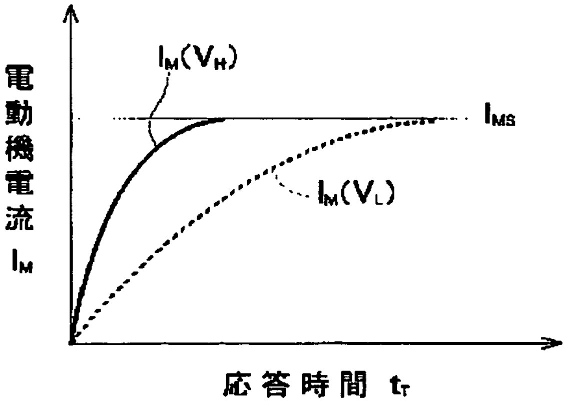
[Drawing 3]



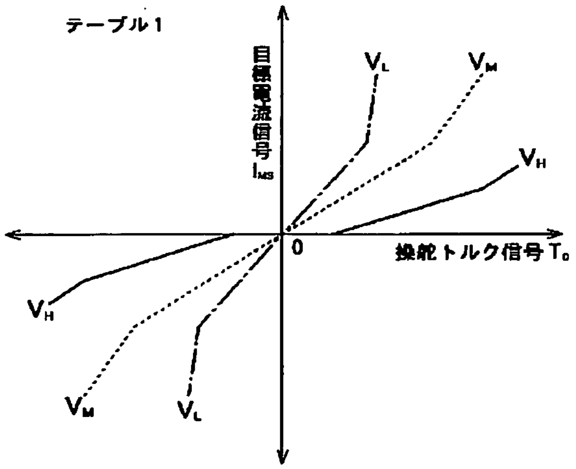
[Drawing 5]



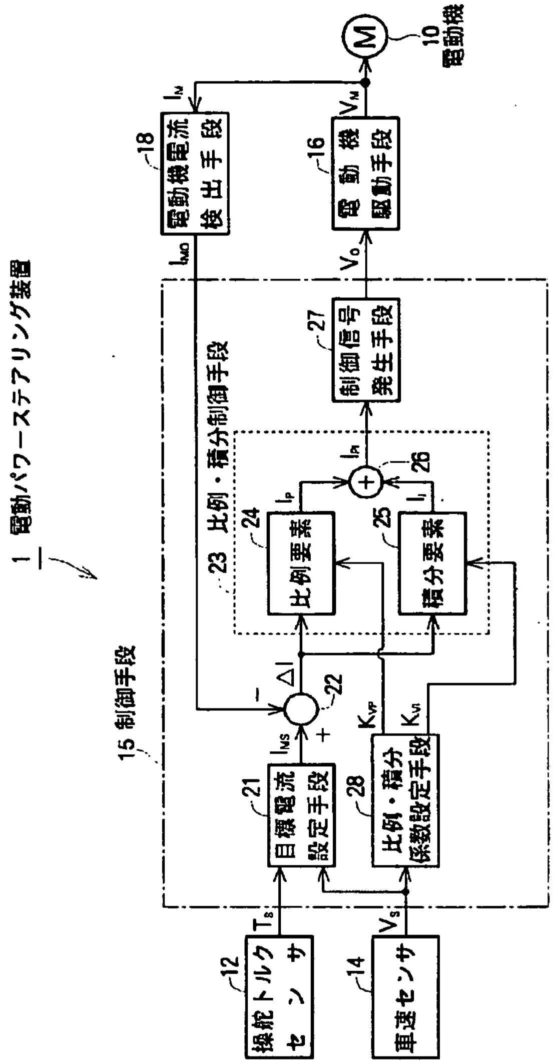
[Drawing 6]



[Drawing 8]



[Drawing 2]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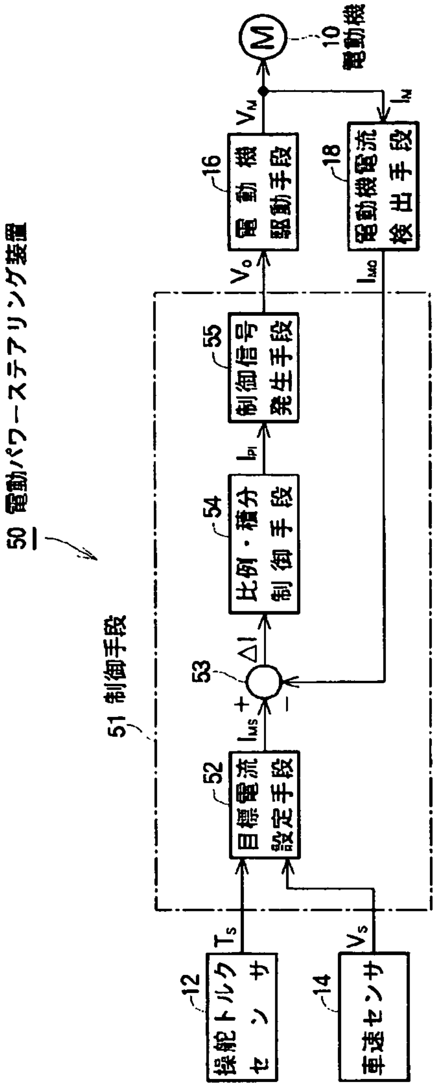
15 制御手段
23 比例・積分制御手段
12 操舵トルクセンサ
14 車速センサ
T_S
V_S
21 目標電流設定手段
28 比例・積分係数設定手段
I_{MS}
+
−
22
ΔI
K_{VP}
K_{VI}
24 比例要素
25 積分要素
I_P
I_I
26
I_{PI}
27 制御信号発生手段
V_O
16 電動機駆動手段
V_M
18 電動機電流検出手段
I_M
I_{MO}
M
10 電動機

[Drawing 7]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51 制御手段
12
操舵トルクセンサ
14
車速センサ
T_S
V_S
52
目標電流設定手段
I_MS
+
−
53
ΔI
54
比例・積分制御手段
I_PI
55
制御信号発生手段
V_O
16
電動機駆動手段
V_M
M
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電動機
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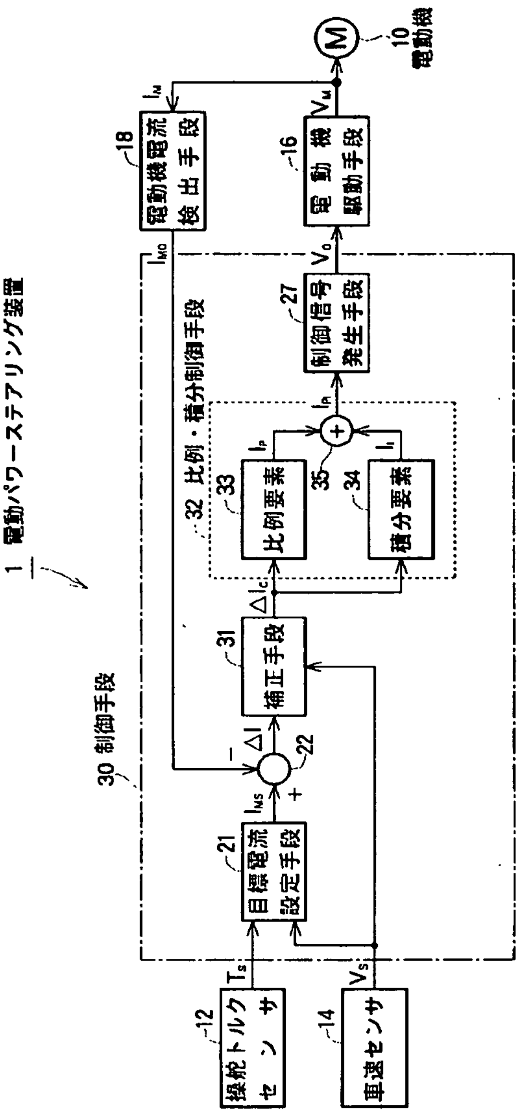
電動機電流検出手段
I_MO

[Drawing 4]


1 電動パワーステアリング装置
30 制御手段
12 操舵トルクセンサ
14 車速センサ
T_s
V_s
21 目標電流設定手段
I_MS
+
−
22
ΔI
31 補正手段
ΔI_C
32 比例・積分制御手段
33 比例要素
34 積分要素
I_P
I_I
35
I_PI
27 制御信号発生手段
V_O
16 電動機駆動手段
V_M
M
10 電動機
18 電動機電流検出手段
I_M
I_MO

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